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Current state of wind energy in Mexico, achievements and perspectives

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ABSTRACT

The Mexican government has made a serious commitment to include wind energy in its energy policy. It aims at reducing the dependence on fossil fuels for the generation of electricity and thus cut down the emissions of environmentally harmful gases. The generation of electric energy from renewable sources, apart from hydraulic and geothermal ones, is still limited despite the potential available throughout the territory. However, wind energy has joined the energy basket as one of the viable alternatives in the short and medium term. The objective of the Infrastructure National Program of the Federal Government for 2012 is to achieve that 5% of the electricity generated will come from the wind. To offer an up-to-date view this article reviews the state of wind energy in México, the achievements, perspectives and current limitations for its future development.

Contents

1. Introduction

Mexico is located in the tropic of Cancer, to the north sharing borders with the United States of America and to the south with Belize and Guatemala. Its western coastal line faces the Pacific Ocean and the eastern the Gulf of Mexico and the Caribbean Sea. It is 1,964,375 km^2 wide and has a population of 106,682,518 inhabitants [1].

México is a country were there are considerable renewal energy resources [2–10] and so the General Ecological Balance and Environmental Protection Law has been passed, in which the necessity of taking steps, "that lead to the present generation's welfare without compromising the fulfilment of future generations' needs" is affirmed [11]. This is the reason why renewable energies must play an important role.

Currently, hydraulic and geothermal resources are, among the renewable resources, the ones that make a greater contribution to the Mexican energy mix. This is due to the number of lakes and lagoons, the hundreds of rivers that end in the nearby Oceans and also the important geothermal exploitations located in the central areas of the country.

Mexico has a rugged landscape with mountainous areas, a volcanic axis, valleys, plains and high plateaus, which results in a variety of climates that go from the dry climate in the north to warm-humid and sub-humid climates in the south and south-east. The colder climates can be found in the high lands of the interior.

Regarding wind energy and according to the new technological advances and investigations carried out by the Electricity Federal Commission (CFE) and the Institute of Electric Investigations (IEE),

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Mexico has an estimated wind energy potential that ranks between 3000 and 5000 MW, which would represent 10% of the capacity currently installed throughout the country [12].

In order to benefit from this resource, the Venta II wind energy park began working on January 5th 2007. It is composed of 98 wind turbines with a total capacity of 83.3 MW. It is the biggest wind energy park installed in Latin America, which puts Mexico as the second country in Latin America in installed wind power (402 MW), only behind Brazil with 600 MW [13–17].

The development of wind energy for electricity generation will mean a reduction in the dependence on fossil fuels for electricity generation and so it will reduce the emission of gases responsible for the greenhouse effect. Consequently, this type of energy occupies a very important place in the energy policies of the country, as can be seen in the National Development Plan 2007–2012 [18,19].

However, the legal framework in which the renewable energies have to subsist is the same as for the traditional energies. This implies that the degree of exploitation of these resources will strongly depend on competition in terms of price and quality.

2. The energy system in Mexico

The Mexican energy system is based on petroleum-based products. 90% of the primary energy production in 2008 consisted of hydrocarbons, 4.4% of electricity, 3.3% of biomass and 2.4% of coal, when added together making a total of 10,522 PJ [20].

Crude exploration, perforation and extraction activities belong to the nation, they are a national monopoly, Mexican Petroleum (PEMEX) is the company in charge of exploiting the resource. With regard to the electricity sector, there are both public and private ones. The latter were made possible by changes introduced in the regulatory framework of the electricity sector, which allowed the participation of private investment, thus introducing into electricity generation such factors as Independent Producers (IP), cogeneration, self supply, import and export.

In 2009, the total power of Mexico reached 51,686 MW out of which 77.84% came from geothermal resources, 22% from hydraulic and 0.16% from wind energy. The amount of generated electricity was 233.47 TWh, of which 88.57% was thermoelectric, 11.32% hydraulic and 0.11% wind energy (Fig. 1) [18].

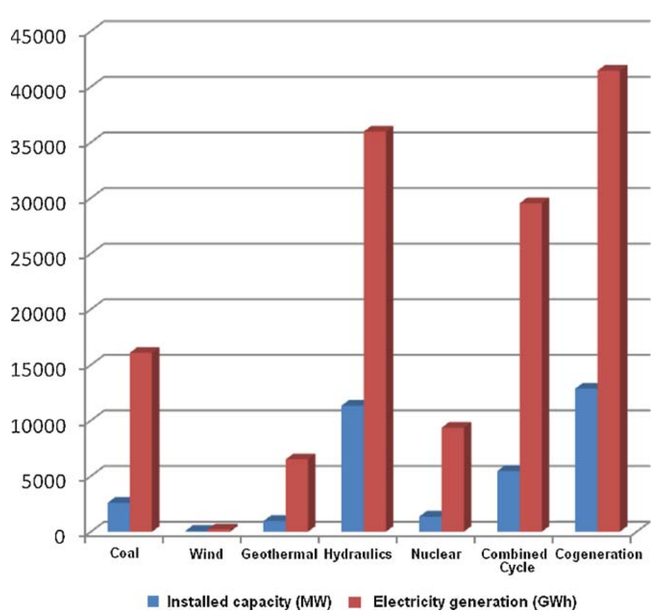


Fig. 1. Installed power and electric generation of SEN without independent producers.

This capacity allows 97.33% of the population to have electricity, leaving 3 million people spread over rural areas without it [21].

3. Institutions and legislation regarding the spreading of renewable energies in Mexico

The institutions responsible for co-ordinating the working of the energy sector are:

- The Secretary for Energy (SENER): the department of energy is the government institution in charge of regulating energy policies.
- The Regulatory Board for Energy (CRE): Energy Regulating Committee is the main regulating agency in the electric and gas sector.
- The Federal Electricity Board (CFE): Company which generates, transports, distributes and supplies electricity to the National Electricity Service (SEN) [22].

To boost the development of renewable energies and energy saving, specific institutions were created such as [23]:

- The National Committee for the efficient use of energy (CONUEE) in charge of promoting the use of renewable energies and energy saving.
- The Institute of Electric Research (IIE), which researches specific unconventional energy generation and investigates development of tools to aid these unconventional technologies.
- The trust for the Electric Energy Saving (FIDE) which offers orientation and technical support and provides financial services for energy saving.
- The Trust of Shared Risk (FIRCO) which supports the programs for rural development that integrate the use of these technologies for agricultural and economical activities.

There are other institutions that carry out studies and programs aiming to support the strategies in energy matters like the Mexican Association of Wind Energy (AMDEE) and the national Association for Solar Energy (ANES), among others.

Until recent years in Mexico the private sector was denied participation in electricity energy generation and there were laws regulating the renewable energies sector, which caused its development to be limited to educational and trade fair projects.

In 1992 a new regulation of the law of public service of electric energy was approved, which at first did not allow the free purchase of energy between private institutions, but this modification allowed the participation of the private sector aiming at increasing the capacity installed under certain modes: independent producers, self supply, co-generation, small production, import and export. The first ones were the ones that recently have developed projects regarding renewable energies.

Regarding the regulation of renewable energies the electric sector has taken an important step when approving in October 2008 the Law for the effective use of Renewable Sources (LAFRE), which establishes for 2012 an 8% participation of renewable energies in the total of electricity generation without including the major hydroelectric centrals (with power exceeding 30 MW) [24].

In the matter of wind energy, in December 2006 the Mexican Official Regulations PROY-NOM-151-SEMARNAT-2006 were published. They establish the technical specifications for the protection of the environment during the construction, operation and abandonment of wind energy facilities in agricultural, livestock and wasteland areas [25].

4. Wind energy in Mexico

The generation of electric energy from renewable sources, except for the great hydroelectric and geothermal centrals, is still limited despite the available potential throughout the territory. Nonetheless, wind energy has been added to the energy basket as one of the most feasible alternatives in the short and medium term. This is due to the fact that in recent years technology has reached levels of development, resulting in a great reliability in the employment of equipment and machines with high safety standards and allowing the start of projects that have increased the installed power at international level [26].

In the search for alternatives to energy diversification Mexico has put forward an energy scheme that includes the installation of wind energy parks in different areas where, due to their natural conditions, there is a plentiful supply.

4.1. Areas with usable wind energy resource

The Mexican territory has areas where the land strips become narrow and as a result are surrounded by great bodies of water. Therefore there are areas where the difference of pressures between cold air pockets from the seas and the hot air pockets over dry land originate wind gusts with optimum speeds and densities to be efficiently used as a renewable energy resource.

The different studies related to wind energy development in Mexico are still at an exploratory and investigatory level, but the measurements carried out confirm the existence of areas able to be used and economically feasible for the construction of wind energy parks.

Up to date ten areas have been identified where the wind energy resource is quite abundant. Studies carried out by the Renewable Energy Laboratory of the US Department of Energy, CFE and several Mexican institutions have estimated wind potential over 40,000 MW in Mexico, distributed along the Low California peninsula, central region, Gulf coast region, Yucatan peninsula and the Isthmus of Tehuantepec. The latter is one of the best areas, not only in the country, but also in the whole American continent. It has average wind speeds over 8.5 m/s measured at 50 m height with a potential of 6250 MW and other speeds between 7.7 and 8.5 m/s, with a potential of 8800 MW (Fig. 2) [27].

4.1.1. Oaxaca

The state is affected by the influence of three prominent wind flows: northeast north wind from October to February, east wind from March to May and east trade wind from June to September.

Wind energy resources are characterized according to their speed on a scale that goes from class 1 to 7 (Table 1) [4]. Different areas in the state of Oaxaca have been identified for the development of wind energy on a commercial scale (class 4) and for rural areas or areas outside the network (class 2) where the required wind speed is no more than 6 m/s.

The areas with the best wind energy resources in Oaxaca are concentrated in the southeast region of the state in the south part of the Isthmus of Tehuantepec with class 5 wind type scale. Class



Fig. 2. Zones with the highest wind potential in México.

Table 1
Wind type scales by the National Renewable Energy Laboratory [4].

Class	Resource potential (commercial scale)	Wind power strength (W/m^2) a 50 m	Wind speed (m/s) a 50 m
1	Poor	0–200	0.0–5.3
2	Scarce	200–300	5.3–6.1
3	Moderate	300–400	6.1–6.7
4	Good	400–500	6.7–7.3
5	Excellent	500–600	7.3–7.7
6	Excellent	600–800	7.7–8.5
7	Excellent	>800	>8.5



Fig. 3. Areas with the best wind energy potential in the state of Oaxaca.

7 winds are located in the isthmus hills, including the areas of La Venta, La Ventosa and La Mata (Fig. 3) [4].

4.1.2. Baja California

The Baja California peninsula is another interesting region for the development of wind energy, the presence of air currents that come from the Pacific perpendicularly has an effect on the state's coastal region. Some studies point to the area of El Cardón in the south of Baja California. Other areas are la Laguna de San Ignacio, San Juanico and Punta Eugenia where preliminary studies have been carried out. The CRE estimates a potential close to 274 MW in the ranges called La Rumorosa and San Pedro Mártir (Fig. 4) [24].

4.2. Wind energy projects and/or programs

To increase the effective capacity of the SEN and develop wind energy in Mexico, the Institute of Electric Research together with the UN Program for Development have produced their "Action Plan for eliminating barriers for the development of wind electricity generation in Mexico", based on four goals: development of capacity, creating and demonstrating projects, analysis and proposal of improvements to the legal or institutional framework, the promotion of cooperation, and increasing links and effort.

According to the CRE, mid-2010 there were 22 licences to install more than 900 MW in wind energy parks granted to the private sector for self-supplying.

The CONUEE in its wind energy section claims that Mexico will start a development program for wind energy parks aiming at reaching a maximum effective capacity of 5000 MW by 2010, which is considered a feasible and necessary goal. This goal will suppose an annual generation of 13,140 GWh, which will avoid the emission of 4.6 millions of tons of CO_2 into the atmosphere.

4.3. Current development

Currently the CFE has three wind energy parks that are operative. The biggest is La Venta II with a power of 83 MW. The second is the Guerrero Negro park located in Southern Baja California with a capacity of 0.6 MW and the third is La Venta I with 1.5 MW.

Among the goals of the 2007–2012 National Development Plan 2007–2012 [15], the Isthmus of Tehuantepec's wind energy project has been established in order to place Mexico among the 10 top countries in the world in electrical generation from the wind for 2012. It is the most important project in Latin-America in this renewable energy. This project will be built on 20,000 ha of land in La Ventosa and La Venta where there are 200 turbines already installed.

As part of this project, the Mexican Cement producer CEMEX and the Acciona Company will develop the wind energy park named Eurus. It is the biggest wind energy project in Latin-America and will be carried out by private investment in the self-supply mode. It will have an installed power of 250.5 MW, 167 wind turbines located in the Isthmus of Tehuantepec area on a plot of 2500 ha. As part of this project on January 22nd, 2009 37 MW, 22 wind turbines became operative.

This park will allow the reduction of 600 Mt of CO_2 per year. CEMEX will supply 25% of its necessities with electric energy produced in the park. The park is the biggest of the ones installed by Acciona in the world and means a great boost for the development of wind energy in Mexico [28].

The CFE will also build the La Venta III and Oaxaca I, II, III and IV parks, with these installations the national electric systems would count on with a total of 585 MW from wind in the Isthmus of Tehuantepec by the end of 2012 [29].

The construction of the wind energy park La Venta II has been awarded by the CFE to the Spanish company Iberdrola Renovables, located at Santo Domingo in the state of Oaxaca. The wind energy park will have an installed power of 103 MW, produced by 121 wind turbines, model G52 and supplied by Gamesa Eólica, a company with Spanish capital. It is expected to go into operation by the end of 2010. It will supply an electricity service to almost 200,000 households and it will avoid the emission of 150,000 t of carbon dioxide CO_2 [27].

Likewise at the beginning of June, 2009 the CFE signed a contract with the Oaxaca Renewable Energies consortium (EAO) for the construction of the Oaxaca I wind energy park with an installed power of 101 MW and it is estimated the emission of 150,000 t of CO_2 will be avoided [27].



Fig. 4. Areas with the best wind energy potential in Baja California.

In the state of Michoacan the Mexican company SoWiTec has started studies to determine the feasibility of installing a wind energy park in the port of Lazaro Cardenas, Michoacan. The estimated term for the study of the wind potential is 24 months. An approximate 189 MW power wind park is under project and if the studies turn out feasible the park would be installed in 5 years [27].

Apodaca's town hall in the state of Nuevo Leon has proposed establishing an agreement with the private company "Eólica Santa Catarina", with the goal of having public lights powered by wind energy [27].

In Baja California, the Mexican company Turbopower Services, in a joint venture with the American company D'Quadrant Strategies, has started the construction of the La Rumorosa wind park. The project contemplated a first stage, which was finished in September 2009 in which five 2 MW wind turbines were installed. In the second stage 90 MW will be installed to complete a 100 MW

wind energy park. The energy supplied by this wind park will be connected to the CFE and from there it will supply the public electricity service from the Mexicali and Tijuana town halls. It is currently pending of approval as a project called “Clean development Mechanism”, whose purpose is to obtain income from the sale of Carbon Bonds, in order to avoid CO_2 emissions of over 14,000 t per year [27,30].

5. Political perspective

The progressive implantation of renewable energies demands financial strategies based on incentives and/or subsidies until the programmed power has been reached. Therefore the Government in its Energy Sector Program establishes goals for the promotion of sources of renewable energy and defines policies and financial mechanisms attractive to the private and public sectors [31].

The development of the laws pointed out by this paper for the usage of renewable energies lead to a greater energy diversification and also to the decrease of the environmental impact linked to the sources of fossil origin.

The current working scheme of the Mexican electric sector is conditioned by the public institutions, which have little management flexibility and work with a structure based on electric generation at the lowest possible cost and therefore it will be necessary to establish a proper administrative and tariff regulation. Such regulation must be oriented towards a growing liberalization of the electric market, so the electricity generated from renewable sources, and wind energy in particular, could be introduced into the grid before the ones of fossil origin.

6. Final consideration

Mexico has not been constant in its policy related to the spreading of renewable energies. Due to this fact some sectors of the population are unaware of the advantages of a sustainable energy system, which creates distrust and lack of credibility towards the renewable related proposals at local level. The spreading and information of the projects successfully carried out in Mexico is a way of bringing attention to the country’s capacity to provide places with high rates of marginalization in electricity supply.

The country has research centres in specialized areas for the study of renewable energies. However, it is necessary to invest in $R+D+i$ to consolidate the exploration and reconnaissance studies regarding the existing resource. The technological challenge that Mexico is facing starts with beginning to use Mexican engineering companies to carry out systems and supply equipment. This in the long run would make costs cheaper and promote the creation of jobs requiring different levels of education, including the training of specialized technicians in the energy branch.

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